Exploration for Lead-Zinc in the Selwyn and Mackenzie Mountains Yukon and Northwest Territories*

by

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EXPLORATION FOR LEAD-ZINC IN THE SELWYN AND MACKENZIE MOUNTAINS YUKON AND NORTHWEST TERRITORIES

The Selwyn and Mackenzie mountains are located in the northwestern part of Canada along the eastern side of the Yukon and western side of the Northwest Territories and cover an area of about 150,000 square miles. The mountains are rugged and isolated and up until a few years ago had been penetrated by only a few hardy explorers, trappers and prospectors and an occasional reconnaissance party of the Geological Survey of Canada. However in recent years much of this area has been mapped by the G.S.C. on a one inch to four mile scale, largely through programs relying heavily on helicopter support, and now much more is known about the Selwyn Basin and Mackenzie Platform. Partly as a result of this work the amount of exploration in the area has been increasing.

In 1973, the combination of a number of factors, including rising basemetal prices on the world market, a slowdown of exploration in British Columbia and the announcement of a new lead-zinc discovery in the Summit Lake area, produced an unprecedented amount of exploration activity. During the past field season over 5 million dollars were spent on "grassroots" exploration in this area as companies became interested in the Selwyn and Mackenzie mountains as a direct continuation of the metallogenic provinces of the Cassiar and Rocky mountains. The vast size and diverse geology of this region, within which exploration costs were previously considered prohibitive, now promise a significant mineral potential and make it one of the new frontiers in Canadian

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The first part of this paper will be a synopsis of the geology the Selwyn Basin and the Mackenzie Platform to provide a geogical framework to which descriptions of recent mineral discoveries ill be related. In addition, a quick review will be made of the xploration methods used in 1973 and the results of these programs. inally several high potential areas will be outlined which should rove to be primary targets for 1974 exploration.

The geology of the Selwyn and Mackenzie mountains is characerized by thick sequences of Helikian to Cretaceous clastics and arbonates which become younger toward the east. Clastic rocks, predominantly marine grit and shale, were deposited in the Basin and grade eastward into marine carbonates deposited in the shallow shelf environment over the Redstone Arch. East of the Redstone Arch, the carbonates give way to shales deposited in the deep marine environment of the Root Basin. The shelf sediments consist mainly of limestone and dolomite with local interbedded sandstone, shale, argillite and chert. Of particular interest are the fronts between the deep water shales and the shelf carbonates where reefal carbonate accumulations commonly formed. Such fronts are common here in Lower Cambrian, Cambrian-Ordovician, Ordovician-Silurian and mid-Devonian strata.

The oldest rocks in the Selwyn and Mackenzie fold belts are the Helikian and Hadrynian carbonates and clastics exposed along the core of the Redstone Arch and in the western Selwyn Mountains. Cambrian to Cretaceous successions fill the remainder of the Selwyn and Root basins and drape over the Redstone Arch.

Cretaceous granite plutons intrude the sedimentary sequences near the Northwest Territories-Yukon border. A line along the eastern edge of the intrusions marks the geological boundary between the Selwyn Fold Belt and the Mackenzie Fold Belt. There are no igneous rocks east of this line within the Mackenzie Mountains.

Very little marine deposition occurred during the Cenozoic, a period marked by widespread tectonic activity. Mountain belts formed during the Columbian Orogeny were rejuvenated and together with new belts, underwent uplift during the Laramide Orogeny in Upper Cretaceous and Oligocene time. This tectonism structured the Mackenzie Mountains into a north-northwest trending arcuate belt of broad folds characterized by nearly flat crests and troughs with upturned and thrust-faulted flanks. The thrust faults are commonly located along the middle and forelimb of the folds and terminate at small tear faults orientated along an old, possibly basement controlled, fracture system.

During the past field season, numerous lead-zinc showings were found throughout the Selwyn and Mackenzie mountains. I will describe the type mineralization found within the four main areas, the Summit Lake area, the Bonnet Plume Lake area, the Godlin Lakes area and the Fort Wrigley area. Because the Summit Lake discovery was announced first and was one of the major factors in precipitating the present exploration activity, I will begin the descriptions with it.

Formations in the Summit Lake area were originally mapped by the Geological Survey of Canada as Cambrian carbonate and siltstone unconformably overlain by shale of Devono-Mississippian age. Graptolites of Silurian, Upper Ordovician and possible Lower Ordovician age have recently been identified in the shales and it now appears that deposition may have been continuous, although perhaps limited, throughout Cambrian to Devonian time. Lead-zinc mineralization is contained in black, graptolitic, slightly calcareous shales with local chert, siltstone, dolomite and limestone beds. These shales have been tentatively correlated with the Road River Formation, a time-transgressive rock unit ranging in age from Upper Ordovician to Lower Devonian. The mineralized shale is overlain by up to 3,000 feet of shale, chert, sandstone and chert pebble conglomerate and is underlain by a thinly laminated, wavy banded limestone which is thought to be part of the Upper Cambrian Rabbitkettle Formation. The mineralized shale occurs an estimated 15 miles west of a time equivalent carbonate facies. The mineralization is stratabound and occurs in thin laminated beds within the shale. Sphalerite and galena are the main ore minerals and are so fine-grained that hand samples containing 15 to 20% combined lead-zinc appear superficially like barren shale. Secondary lead-zinc minerals such as smithsonite, cerussite and especially hydrozincite may occur on the weathered surface of the mineralization and have been observed in several places in talus downslope from the source areas. In addition to secondary min-

rals, a coarse "box-works" texture has developed over some mineralized areas. Prospecting guides such as these are very helpful in the Summit Lake area because of the recessive nature and lack of outcrop of the mineralized shales.

Canex Placer has reported mineralization over a strike length of three miles. Trenching in this zone has exposed widths up to 100 feet containing some individual five foot samples assaying as high as 50% combined lead-zinc separated by lower grade bands. Several additional showings are known to occur on the Canex Placer property which extends for about 24 miles along the strike of the mineralized horizon, but these, as yet, have not been thoroughly examined. Although Placer's development work is only in the primary stages, the exploration geologists are hoping and looking for a high grade stratabound deposit favourable to large tonnage operations.

Another area which received a great deal of attention during the last half of the past field season is located in the northern Selwyn Mountains in the Bonnet Plume Lake area. The geology in this area is marked by abrupt thickening of the carbonates and abrupt facies changes from carbonate to shale and back into carbonate over relatively short distances. A trough filled with shallow marine Ordovician to Middle Devonian calcareous shale opens toward the southeast but is overthrust by Hadrynian clastics before the Summit Lake-type shale environment is encountered. At the base of the Hadrynian there is a large hiatus where the Rapitan Formation overlies Helikian algal dolomites.

To date there have been two attractive mineral discoveries in the Bonnet Plume Lake area, one by Barrier Reef and the other by Cypress Resources. The Barrier Reef discovery is within the Lower Cambrian Backbone Formation which occurs at the top of a thick carbonate package ranging from Hadrynian to Cambrian age. These Cambrian carbonates abruptly thicken in the Bonnet Plume Lake area and change northeastward into shale. The Backbone Formation carbonates are also bordered by shales stratigraphically both above and below. Mineralization occurs predominantly in breccia zones within dolomite and consists largely of low iron, light coloured sphalerite with minor amounts of galena, pyrite, and some boulangerite. Zinc mineralization, found in the associated wall rocks as the carbonate smithsonite, is exposed for some distance on one of the ridges on the Barrier Reef property. Iron sulphides are not abundant and as a result no rusty gossans have developed. However the entire showing has a distinctive pastel lemon yellow colour marked by white patches where quartz debris has accumulated.

The Cypress deposit occurs roughly 5 miles west of the Barrier Reef deposit in a carbonate unit which tails off abruptly into shale. The mineralization occurs near the top of a pisolitic carbonate unit similar to that of the Barrier Reef deposit, but the Cypress deposit is located approximately 1000 feet stratigraphically below the latter in the Hadrynian Sheepbed Formation. Both these discoveries occur at the top of thick carbonate sequences

in an area where stratigraphic thickness and facies change abruptly. Mineralization occurs mainly in breccia zones within carbonate host rocks and although the characteristics of the breccia zones have yet to be determined, the extent of the mineralization in the discovery outcrops is very encouraging. It is anticipated that the Bonnet Plume Lake area will be the focus of intense exploration activity in the coming field season.

Increased exploration activity took place in the Godlin Lakes area during the past summer. Recent mapping by the Geological Survey of Canada has shown this area to be underlain by a northwest trending synclinorium of dominantly Paleozoic strata. Cambrian carbonates and clastics rim the margin of this synclinorium and grade stratigraphically upward into younger Ordovician, Silurian and Middle Devonian carbonates toward the core of the synclinorium. Lateral facies changes of carbonate grading into shale are common in this area. Abundant north to northwest striking thrust faults also complicate the geological picture and, in one fault block near the centre of the synclinorium, have preserved a sequence of Cretaceous coal-bearing clastics.

Regional exploration by Welcome North Mines has uncovered numerous showings within Lower Cambrian to Middle Devonian shelf carbonates. These showings can be divided into vein type and stratabound type mineralization. Spectacular, high grade showings of galena and sphalerite are found in cross-fractures adjacent to northwest striking thrust faults. These veins are not confined to any one unit, but rather occur in a number of Silurian

and Devonian dolomite and limestone formations. In places showings are found intermittently along a strike length of up to 5,000 feet but are typically erratic and discontinuous. Many of the higher grade showings have a cap of smithsonite and cerussite.

Stratabound mineralization occurs in the Godlin Lakes area within a bright-orange weathering dolomite unit of the Lower Cambrian Sekwi Formation. Some sections of the Sekwi dolomite are extremely vuggy; and galena, minor sphalerite and pyrobitumen accumulate in the vugs. This type of mineralization occurs adjacent to black calcareous shales which have been faulted into contact with Sekwi dolomite. Recent stratigraphic studies by the G.S.C. have outlined three zones within the Sekwi dolomite which are differentiated by subtle changes in the fossil fauna; an inner detrital zone, a middle carbonate zone and an outer detrital zone. The mineral occurrences in the Sekwi Formation near Godlin Lakes appear to occur along the edge of the outer detrital zone.

The stratabound-type mineralization within the Sekwi Formation drusy dolomite has more economic potential than the vein-type mineralization because of its higher tonnage possibilities. However, insufficient exploration work has been done in the Godlin Lakes area to even vaguely assess the economic potential of either type.

The Wrigley area, another location of Pb-Zn exploration in 1973, lies in the front ranges of the Mackenzie Fold Belt, just west of the Mackenzie River. The area is underlain by relatively flat-lying recessive Upper Devonian shales except where Cambrian to Middle Devonian carbonate, shale and sandstone are exposed along the major north trending thrust faults.

Galena and sphalerite with minor amounts of smithsonite, cerussite and hydrozincite occur in Middle Devonian limestone and dolomite along north trending fracture zones which parallel the major fold axes in the area. Adjacent to the fracture zones, the limestone may be extensively dolomitized and silicified, an alteration which usually indicates nearby mineralization. A notable exception to this is the Bear Rock Formation located east of the Mackenzie River where extensive alteration and brecciation have occurred but no mineralization has been found.

In summary, the recently discovered lead-zinc occurrences in the Selwyn and Mackenzie mountains consist of three basic types; fracture controlled type similar to those found in the Fort Wrigley and Godlin Lakes areas, stratabound type in Lower Cambrian dolomite exemplified by the Godlin Lakes discoveries, and stratabound, shale-host type in the Summit Lake area. Mineralization in the Bonnet Plume area may be stratabound, but until more is known about the nature and distribution of the host breccias, its classification is uncertain.

Now that the main types of lead-zinc occurrences have been described I will review the exploration methods that were used last summer. The effectiveness of any one type of exploration method within the Selwyn and Mackenzie mountains depends largely upon the host rock of the mineralization because the host usually governs the amount of outcrop and the type of topography.

Geophysics as an exploration tool has not been successful. The rugged terrain inhibits the effectiveness of conventional airborne geophysics. Ground magnetometer, gravity, IP and EM were attempted in the past two summers but these methods had limited success.

Visual prospecting is very effective in the carbonate areas such as the Bonnet Plume and Godlin lakes areas where exposure is excellent and the sphalerite and galena can be readily recognized on fresh surface. Visual ground prospecting was by far the most popular exploration method used. The most productive prospecting areas are along skree slopes and creek bottoms where a wide assortment of the nearby rock types is available. Once mineralized float is located it is usually a simple matter of tracing it up-stream or up-slope to its source. However, sphalerite, galena and smithsonite can be exceedingly difficult to recognize. Their weathered surface can be indistinguishable from that of the abundant limestone and dolomite. This is particularly true for sphalerite, much of which is low in iron and hence light-coloured. Therefore it is essential to continually

break rock in order to obtain a fresh surface on which the minerals can be more easily recognized. Some prospectors (and geologists.) carry a dithizone solution which stains secondary zinc minerals red. This solution (3% potassium ferricyanide, 3% oxalic acid and 0.5% diethylaniline in equal volumes) is available from chemical laboratories and can be carried in plastic squirt bottles in the field.

Visual prospecting for mineralization in the shales, such as near Summit Lake, can be exceedingly ineffective because the rock exposure is limited and the mineralization is very fine grained. In these areas of abundant shale, exploration geochemistry is used to best advantage. Widely spaced stream sediment samples are taken for regional reconnaissance geochemical evaluation while closely spaced soil and rock samples can provide effective detailed property coverage. The usual problems associated with geochemical exploration such as pH changes, variable background levels, and transported overburden can be alleviated by careful zinc monitoring. Zinc is highly mobile due to its solubility and has proven very useful in regional geochemical programs. Lead analyses are more useful in detailed property surveys where its limited mobility can closely outline the extent of the mineralization.

Since the Selwyn and Mackenzie mountains contain abundant shale and carbonate, a combination of visual prospecting and geochemical exploration methods provide the most effective grassroots exploration program.

The ruggedness and isolation of the area presents major obstacles in mounting an exploration effort. The logistics of maintaining and operating the infra-structure of an exploration program can be expensive, as even the smallest program generally requires helicopter support. Transportation costs alone for regional reconnaissance can run as high as $1000/day or more, depending on the size of the program.

Because the Selwyn and Mackenzie mountains cover a large area and contain a wide variety of geological environments, it is useful to outline the target areas of highest potential in the hope of increasing the possibilities of success of an exploration program. To conclude I will mention five target areas which have not, as yet, been systematically explored but which have geology similar to that of the areas containing the recently discovered deposits.

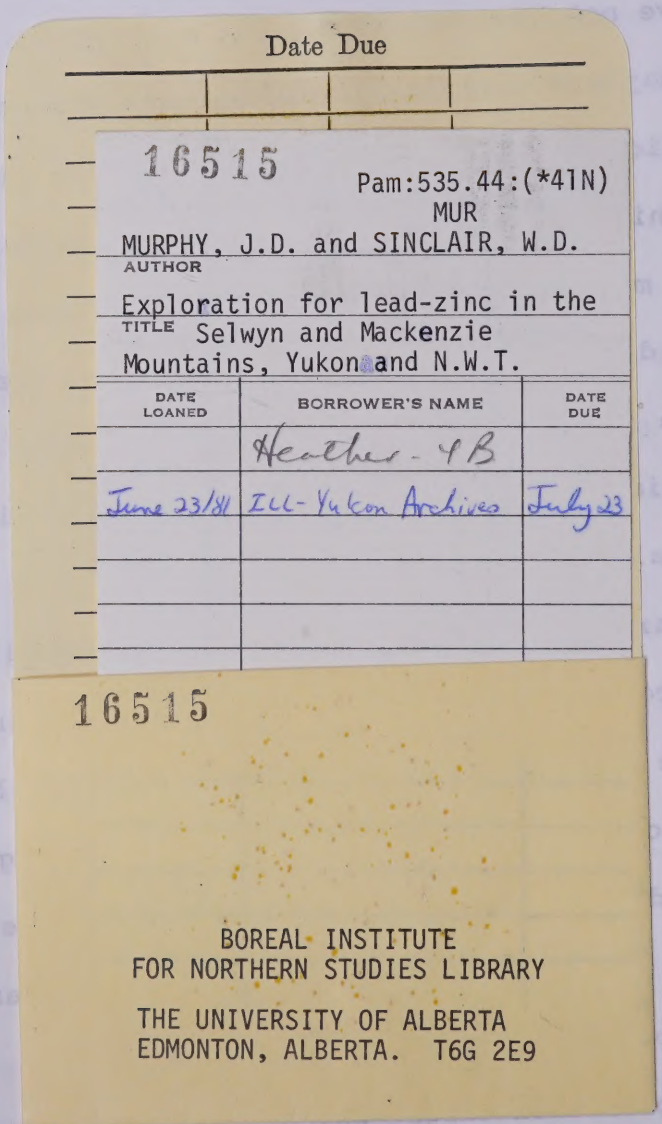
One area of high potential is a wide strip along the western side of the Mackenzie Mountains. This area covers the major carbonate-shale transitions in which reefs are abundant and includes mid-Devonian strata which may contain environments similar to that at Pine Point. Also near these carbonate-shale boundaries, the basinward extensions of the shale could contain deposits similar to the Summit Lake occurrences. The Road River shale is the main target and offers excellent exploration opportunities south of Summit Lake in the Hyland River area.

Another region with good potential is located in the Bonnet Plume Lake area. Recent discoveries made here lie near the top of thick carbonate sequences in an area of abrupt facies changes. Large areas with similar geology west and northwest of Bonnet Plume Lake have not been explored.

A third major target is the widespread Sekwi Formation dolomite in which numerous lead-zinc occurrences have been discovered. This Lower Cambrian formation seems particularly favourable for mineralization in areas of extensive thrust faulting where drusy dolomite is faulted against black shale. Both the Godlin Lakes area and the Snake River area contain an extensive Cambrian carbonate sequence, offering good opportunities for mineral discoveries.

A fourth target is the basin "grit units" found predominantly within central and eastern Yukon. These Hadrynian clastics contain carbonate lenses which are favourable for mineral deposition. Mineralization located in this geological environment would likely be the most difficult of the five to find because the grit units are generally recessive and are extensively overburden covered.

The last exploration target which I will mention, the Bear Rock Formation, is located east of the Redstone Arch along the Mackenzie River. This formation is extensively brecciated, dolomitized and silicified and appears to be an excellent host rock for lead-zinc accumulations. Little exploration activity



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has been concentrated on this area and no mineral deposits have yet been found.

In summary, the Selwyn and Mackenzie mountains are a vast area underlain by thick sequences of marine clastic and carbonate units. These rocks appear to be very favourable hosts for lead-zinc mineralization as indicated by a number of recent discoveries, virtually all of which were found by either visual prospecting or regional geochemistry. Costs attributable directly to isolation and ruggedness are extremely high but may be more than counterbalanced by the untapped mineral potential of this virtually unexplored area. No one expects a mine to be found on every mountain but the discovery of a number of significant deposits should be expected over the next few years.